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ABSTRACT

Thirty hearing impaired students (11-14 years old) participated in a study to measure classification principles using demonstration or display of labels containing relevant words or iconic signs. Three methods of teaching classificatory principles were employed: demonstration, verbal labels, or iconic labels. Analysis of mistakes made by Ss revealed that in each case the use of iconic signs guaranteed better results. Iconic signs allowed for a more precise definition and a better separation of a part from a larger whole than did verbal signs. (Author/CL)

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DEVELOPING SYMBOLIC THINKING IN HEARING-IMPAIRED CHILDREN

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Abstract

The tight conjunction of thinking and language seems to be evident. In the majority of studies on deafness, the troubles in development of symbolic and abstract operations are treated as a result of the lack of sound language. The language acquired by the normal children in direct interaction with the speaking environment, enables him to benefit from social experience. Deaf children grow up to a large extent without such ready-made systems of symbols and are therefore mostly dependent on their own intentiveness for mental activity. Studies dealing with abstract thinking have demonstrated that the abstraction level of deaf children was in these respects inferior to that of normal children. Generally, authors of these studies (Oleron, 1951; Vincent, 1957; Myklebust, 1964; Pettifor, 1968) have been inclined to explain the data by referring to language deficits in the deaf as the main responsible factor.

The main topic of this study was discovering a classificatory principle by 11-13 year-old deaf children by means of demonstration or display of labels containing relevant words or iconic signs. Each introductory label with verbal or iconic sign as well, has considerably facilitated the discovery of classificatory principles. Learning procedure based on verbal signs demonstrates poorer results than the employment of iconic signs, however. The kind of errors indicates the most probable reason for that significant worsening. Series of errors have been observed, concerned with poor processing of information inherent in verbal symbols.

By employment of three methods of teaching classificatory principles (i.e., by demonstration, verbal labels, or with iconic labels) it was shown that the optimal result derives from iconic signs at the beginning, verbal signs as the second trial and a demonstration of task at the end.

Analyses of classification tasks have shown that iconic signs are better memorized and more operational than the verbal ones. The symbolic sign may make natural sign languages useless as a device of symbolic thinking; however, further study is needed.

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Introduction to the Problem

In the face of the generally unsatisfactory results of rehabilitation and education of the deaf, psychologists continue looking for efficient methods of guiding the intellectual development of, especially, deaf school children.

The most controversial problem in psychology of the deaf appears to be the problem of abstract thinking or, as some prefer, of more advanced intellectual operations, the difference resulting from various understandings of the relationship between thinking and speech. This relationship seems to be settled in general and developmental psychology, whereas it is not so unequivocal in the light of the studies undertaken by defectology.

So far, all the experimental studies carried out on the abstract thinking of the deaf have proved that they were inferior in this respect compared with the hearing. In the sixties authors such as Oleron, Vincent, Myklebust, Pettifor and others generally tended to explain the lower level of abstract thinking of the deaf as having its roots above all in language deficiency and only then (for some scholars) in such factors as passive mental set of the deaf, weak spontaneous motivation for intellectual effort, lack of initiative and creativity, schematism and rigidity of thinking.

It is a fact that the majority of deaf children grow without acquiring ready verbal symbols from their associates. Accordingly, all intellectual operations which normally require such symbols either should not develop at all in the case of the deaf or should be tardy, provided a deaf person mastered to some extent the system of language.

Those convictions have allowed us to form a rather simple conclusion which meets the needs of special schools for the deaf: The improvement of advanced forms of intellectual activity can be achieved by means of teaching sound language which seems to be in itself the best system of symbols and rules of their usage.

The effort required to carry out this aim has been great indeed, although even simple research would show that the results of this effort are incommensurable with the expenditure of work. For instance, experiments and longitudinal observations carried out in Polish schools for the deaf (see Note 1) indicate that a decisive majority of 9-10 year-old children are not able to use a written text, whereas their spoken language is too poor to allow them to communicate with their hearing associates and among themselves. Most willingly they use a primitive natural sign language interspersed here and there with single elements of sound language.

When ten years ago we became interested in the problem of categorical thinking, we knew a fairly large amount about those difficulties.

The way that a person classifies (or categorizes) is an excellent touchstone of the level and quality of his intellectual processes. We may learn what criteria one uses when analyzing the way one sorts out, separates or combines classes. A normal seven-year-old child is able to cope with classification following changing criteria; i.e., he is not only able to divide things judging by their specific features but when the need arises, he knows how to nullify this division and how to plan another one according to another criterion.

To place an object in a certain class requires noticing in it a feature (or a combination of features) whose presence decides on its appertaining to this class. A change of criteria and of the kind of classification of the same objects requires looking at them in a different way, taking into consideration other features (for instance a change from colour to shape or to size). According to Berlyne (1969), thinking about affiliation with a class and about inclusion in classes concerns objects and their classes which a child has not got in front of him and which have to be symbolized. The features of the objects whose existence may become a criterion of a belonging to a class are likely to become independent,

a fact which makes it possible to perform certain operations only when they are represented by means of symbols.

The aim of school teaching is to widen and to systematize a child's knowledge. That is why the process of learning requires constant categorization, most frequently according to imposed conventional and not direct criteria. The criteria which suggest themselves directly to the child usually are of a perceptive illogical character. In a normal situation it is the language which plays the role of a medium between the child's experience and a convention it is to adopt. On the other hand, in the case of the lack of hearing, one may expect that the difficulties in mastering the system of language should result in some difficulties in classifying operations of the mind.

Now let us quote the theoretical conclusions by some psychologists concerning the above problem:

> - Hofler (1927) - "In the face of the multitude of features among which one is expected to discover certain categories, words which correspond to those categories may be helpful and may allow a more detailed and more flexible classification."
>
> - Oleron (1951) - "Once classification becomes more abstract, speech exercises its influence, especially on multifarious classification where the inferiority of the deaf has been demonstrated."
>
> - Vincent (1957) - "The tardiness of the deaf indicates that insufficient development and usage of language impedes the performance of this task (classification)."

Both Oleron and Vincent add that the handicap of the deaf in the sphere of categorical thinking results not so much from the lack of certain verbal symbols, since the fact that a deaf child knows a word does not put him on a par with a hearing child. A normal child hears a given word in various situations and contexts, it assimilates its various meanings, whereas a deaf child meets words in a limited context, his experience is fragmentary, and a word, usually connected with a concrete situation, does not help him to generalize.

Pettifor (1968) studied deaf children's abilities to classify pictorial material both on the basis of sensual perception and on the basis of their ability to use notions. It appeared that in both cases, that is on the visual plane and still more on the notional plane, hearing children aged 5;10 to 14;1 decisively surpassed their deaf counterparts. Similar results were achieved in the studies of Polish deaf children aged 7 to 11 (Cieszynska, 1979).

The test consisted in classifying geometrical figures and building bricks, and it required the children to form classes, to discover a criterion which determined a class already existing, and to switch from one criterion to another. The analysis of the results proved that in the sphere of hierarchical classification the deaf pupils were on the average three years behind their hearing counterparts.

In relation to Pettifor (1968), we should notice that her interpretation of the results remains in agreement with the opinions of her predecessors (for instance of Oleron and Myklebust) and she clearly states that: "...the results obtained show that higher levels of thinking depend on the development of language, whereas its retarded development clearly influences in a negative way the level of the development of higher forms of thinking."

However, the author does not confine herself to this statement, but she also points to a very important phenomenon--it appeared that the achievements in the sphere of abstract and notional thinking become higher in deaf children following their growth in age (though they were still lower than at the same age in hearing children), whereas the indices of language development did not increase to the same degree.

We can therefore conclude that the development of certain forms of abstract thinking is facilitated by verbal language, but is not entirely dependent on it.

We may assume that the development of abstract thinking in the deaf may be determined by some other factors such as non-auditory system of language, that is by sign language.

Furth (1966) assumes a different view in comparison with the previous ones: contrary to a common belief he holds that basically intellectual processes do not depend on language. Referring to Piaget, Furth points out that a substantial part of hearing children's intellectual development manifests itself more clearly in wordless than in word symbolism which does, however, not mean that their thinking and intelligent behavior are questioned. If language does not explain (exclusively) intelligent behavior in the hearing, the more so we should not explain and consider the intelligence and thinking of the deaf as dependent on language.

According to Furth: "...human intelligence is attached neither to a certain kind of inner images, not to a certain kind of symbols" (p. 197). Now if we ask what sort of symbols are created by the deaf for the sake of their thinking, we may consider visual, kinesthetic, or gesticulative symbols.

As far as the problem of categorical thinking is concerned, Furth states explicitly that logical rational thinking does not require the same system of symbols which exists in a living language used in society, and that it is easier to teach the deaf the principles of logical thinking (e.g., logical classification) referring to graphic symbols.

In the face of so many diverse views of psychologists of the deaf on the role of language in categorical thinking of deaf children, we asked a question: What is the influence of language, understood as an organized system of symbols transmitted by society, on the shaping and level of categorical thinking of deaf children? In fact, this problem boils down to the question: How do various kinds of symbols used by deaf children influence the course of their intellectual operation of classifying?

We found it interesting to check experimentally first, whether the introduction of symbols would raise the level of classification, and secondly, whether there would be any differences in the way of classifying (if so, then of what kind?) depending on the type of symbols used.

In our studies we paid attention to two types of symbols: verbal and iconic. Verbal symbols were introduced to check the influence of teaching sound language to the deaf on the intellectual operations they performed. That is why we selected for our studies older and linguistically more advanced pupils. On the other hand, we chose iconic signs because it is the second, after verbal, group of symbols which man meets in his environment. Iconic signs, universally used in various kinds of pictographs, are characterized by their structural similarity to the objects they denote.

In the first stage of our study we meant to establish basic relations between these two types of symbols and the process of discovering the principles of classification and of learning it. Those experiments revealed hitherto unknown qualities of iconic signs, so we devoted the next stage of the analysis to focusing on possibilities of using those signs in a system containing its inner rules.

Although the results of first stage of our undertaking were already partly published in the Polish Psychological Bulletin and they were presented during the VIII Congress of the World Federation of the Deaf in Varna, it seems worth quoting here the most significant results, as they are inseparably connected with further studies and are the basis of all our considerations and conclusions.

Researching the Most Informative Symbol

The investigations were carried out on a group of 55 deaf children from the 4th, 5th and 6th forms of an elementary special school for the deaf. The children's level of language efficiency corresponded to the mean level in learners, who are being taught sound language since the beginning of education in

school. Selection of subjects was made on the basis of: (1) medical reports and hearing tests, (2) Leiter's test for non-verbal mental level (children with scores below or equal to 2 stens were excluded), (3) the Bender-Santucci organic test. We tended to except from experimental examination: (1) children with brain damage, (2) children who were mentally retarded or border-line cases accordingly to test or teachers' opinions, (3) those whose hearing sufficed to understand environmental speech. For our purposes children, who according to the teachers' opinions and school marks deviated in one way or the other from the average class level, were also excluded. Examined pupils used a combined system of ideographic and dactylographic signs as well as articulated speech and lipreading. This is in fact the most common practice of the deaf in communication with one another and with normal persons. Age of children was from 10 years to 13 years 9 months.

Three experimental variations required classification of blocks differing in four respects: shape, colour, size, and thickness (Figure 1).

In the D (demonstration) variation the subject was to classify the blocks on the basis of a classificatory rule which was previously shown to him by E.

In the I (iconic) variation, iconic signs (graphic labels) were introduced and the subject was to classify the blocks according to them.

The V (verbal) variation required classification on the basis of verbal signs (verbal labels).

The experimental design included three series administered four weeks apart. Each series ran the three variations in varying orders for each group.

Each experiment (variation) started with a preliminary session (i.e., a trial classification) to familiarize the child with the task. In this session all errors were immediately corrected by E.

The preliminary session was followed by the experimental task which consisted of applying the given classificatory rule to a new and a more difficult situation.

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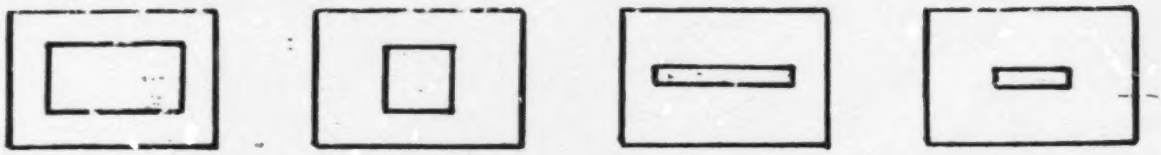
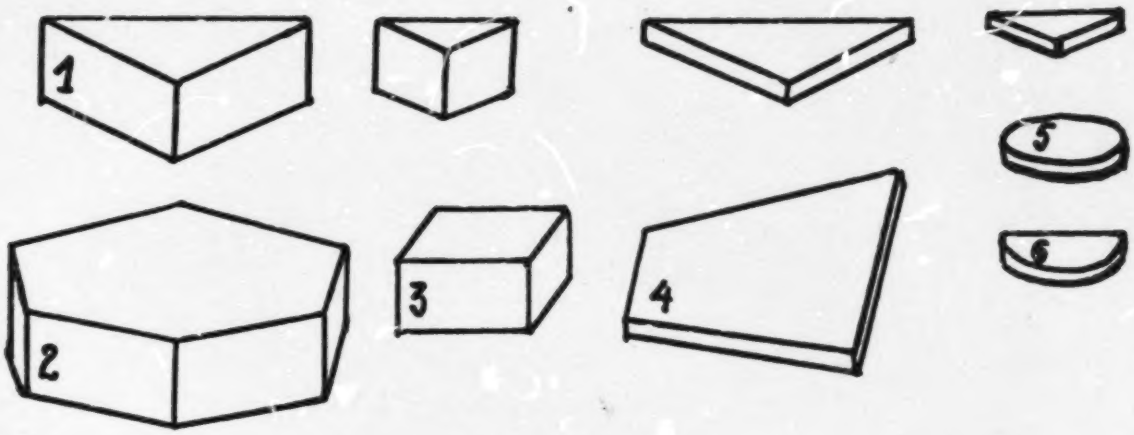
Figure 1.

The experimental labels and blocks.
1). Iconic labels.



2). Verbal labels.

3). Patterns of the experimental blocks.



4). Description of blocks.

Digits indicate the shape, size and thickness as shown above.

"big and thick"	"small and thick"	" big and thin"	small and thin
1 green	1 red	1 white	1 blue
2 white	3 yellow	2 white	1 yellow
3 blue	4 red	3 green	5 yellow
3 red	5 white	4 green	6 green
4 yellow	5 blue	4 red	
5 red		5 blue	
		6 yellow	

In the I variation, four iconic labels were used. These were rectangles differing in base and height. In line with the nature of iconic signs, the labels displayed some visual similarity to the objects they represented (the blocks). In the V variation, labels with verbal signs were used; these were familiar words referring to the relevant differential properties of the blocks ("big and thick," "big and thin," "small and thin," "small and thick").

In each variation the child performed three trials in succession. Errors were corrected after each trial was completed. This procedure permitted the observer to follow the process of learning to classify in each experimental variation. In each trial the number of errors and duration of performance were noted. Scoring protocols were prepared for recording both sequential moves and type of error.

The subjects were distributed among experimental groups as far as possible in a randomized way. Two steps in the analysis of the raw data were followed:

1. First trial scores in the first series, from which to establish the effect of a given sign on learning to apply classificatory learning.

2. Scores over trials, from which to establish effects of classification learning as a process dependent upon the method used. The third trial in Series III would reveal the final learning product.

Classificatory criteria were invariant across experimental series. The subject's task consisted in ordering blocks according to site and thickness, which in effect gave four classificatory principles by themselves (as in the original Vygotsky-Sakharov method), but were provided with the relevant information by either a demonstration or display of labels.

The verbal labels provided full information on the classificatory principle. With comprehension of the words and unimpaired spatial perception no trouble should be met in solving the task. To discover the principle here it sufficed to

read the label. On the other hand the iconic label, as illustration of a classificatory principle, could be ambiguous to a normal person, since an iconic sign includes only some of the structural properties of the represented object. Finally, discovering a classificatory principle from a demonstration should according to our predictions present the greatest difficulty, as blocks used as exemplars have both criterial and irrelevant (colour and shape) properties.

The number of errors was tallied for each trial and a percentage ratio of total errors to total number of blocks served as the index. This type of index was used since there were differences in the number of blocks in the D variation (18) and in the I and V variations (22 blocks each). The indices served as measures of the quality and efficiency of learning.

The results confirmed our predictions. The mean error index for the D conditions amounted to 39.8 and was significantly higher than those for the I and V conditions (22.2 and 23.4) ($p < 0.001$). Use of signs facilitated the discovery of a classificatory principle. Verbal signs were not, however, more helpful than iconic ones (differences in mean error scores in I and V conditions were nonsignificant). A possible explanation is that, for deaf children, verbal symbols are not more informative than iconic signs.

As stated above the experiment was run in three series at four-month intervals. Observed differences in quality of task performance across the series are presented in Table 2.

The results show that classification learning takes place not only over trials but across series as well. Particularly marked differences were noted on comparing first trials of Series I and II. The observed differences testify to the fact that the experimental task was not forgotten during the four-month interim.

Table 1

Mean Error Indices for Experimental Variants D, I, and V in the Three Series

Series	Demonstration			Iconic			Verbal		
	1	2	3	1	2	3	1	2	3
I	39.8	27.5	15.8	22.2	16.9	3.5	23.4	33.5	19.6
II	9.5	3.7	4.3	14.6	21.5	10.8	8.8	13.4	13.1
III	4.6	1.6	0.3	12.2	10.4	1.2	4.5	12.7	12.8

The experimental series did not differ in respect to tasks but only in respect to order of method of solution (demonstration, iconic, or verbal). The series should therefore not be treated separately but rather as three different procedures offering different learning strategies.

Grasping a classificatory principle on the base of a demonstration (the D condition) turned out to be most efficient. True, the first trial of Series I produced the highest number of errors but the number decreased regularly over the next stages and finally amounted to 0.3 in the final trial.

In the I condition, classification learning also followed a fairly consistent course with only infrequent learning disturbances (e.g., error increase in the second trial of Series II). Generally speaking, the error index tended to decrease and amounted to 1.2 in the final trial.

Use of verbal signs produced gross irregularities in learning. Over the three series errors in the second trial increased over the first trial, and differences were significant below the 0.001 level. The final trial in Series II and III did not bring improvement, indicating lack of progress in learning.

It was previously mentioned that verbal and iconic signs were equally facilitative on the evidence of the data on the first trial of Series I. However, since probably the information on classificatory criteria inherent in the verbal sign was not adequately grasped by the deaf children, in the later stages disturbances

in the learning process appeared and the number of errors increased. The explanation was sought in the type of committed errors. It turned out that, except for incidental errors (like lining up blocks with mixed properties), the subjects committed systematic errors across the series. For instance, blocks were lined up in a row according to the correct principle but in the wrong column. This type of error suggests difficulties the subjects encountered in matching words to relevant properties of objects.

A sequence of errors was defined as a row of at least three blocks of the same kind. Table 2 shows the size of error sequences in all trials, both in absolute numbers and percentages in relation to the total number of committed errors. The percentage of sequence errors in the D variation is much lower than in the I and V variations. The highest number of sequence errors characterizes the V condition with a tendency to increase over consecutive trials in each series (the respective percentages for the second and third trials being: Series I - 57.1, 61.7; Series II - 86.2, 79.6; Series III - 83.0, 92.7). The last result shows that incidental errors in the third trial of Series III amounted to 7.3 percent only; the rest were due to sequence errors.

Since the differences in numbers of sequence errors over trials correspond to the respective numbers for general error indices (see Table 1), possibly the jump in errors in the second trial was really due to difficulties encountered in matching the adjectives to referent properties in the objects.

It should be noted that a line-up of six or seven blocks constitutes in fact a systematic classification according to a single criterion, but a different one from that provided by the label (e.g., a line-up of big and thick blocks in the case of a label "small and thin"). It also happened that subjects switched labels once the blocks were put in order, or moved the completed grouping toward different labels. These observations testify to poor processing of the information inherent in verbal symbols.

Table 2

Number and Percentages of Sequence Errors

Series		Demonstration				Iconic				Verbal			
		1	2	3	1+2+3	1	2	3	1+2+3	1	2	3	1+2+3
I.	Σ of all errors	136	84	54	274	83	68	34	185	99	140	81	320
	Sequence errors Σ	15	3	12	30	10	42	21	73	22	80	50	152
	%	11,0	3,6	22,2	10,9	12,4	61,7	61,7	39,6	22,2	57,1	61,7	47,5
II	Σ of all errors	33	16	15	64	61	90	45	196	33	58	49	140
	Sequence errors Σ	6	-	6	12	-	49	23	72	15	50	39	104
	%	18,2	-	40,0	18,7	-	54,4	51,1	36,7	45,5	86,2	79,6	74,2
III	Σ of all errors	14	5	1	20	51	42	5	98	19	53	55	127
	Sequence errors Σ	13	-	-	3	27	39	-	66	3	44	51	98
	%	21,4	-	-	15,0	52,9	92,8	-	67,3	15,8	83,0	92,7	77,1

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The following points summarize our findings:

1. Introduction of iconic and verbal signs considerably facilitates discovery of a classificatory principle.

2. Employment of symbolic-verbal signs produces worse results in classification learning than employment of iconic signs.

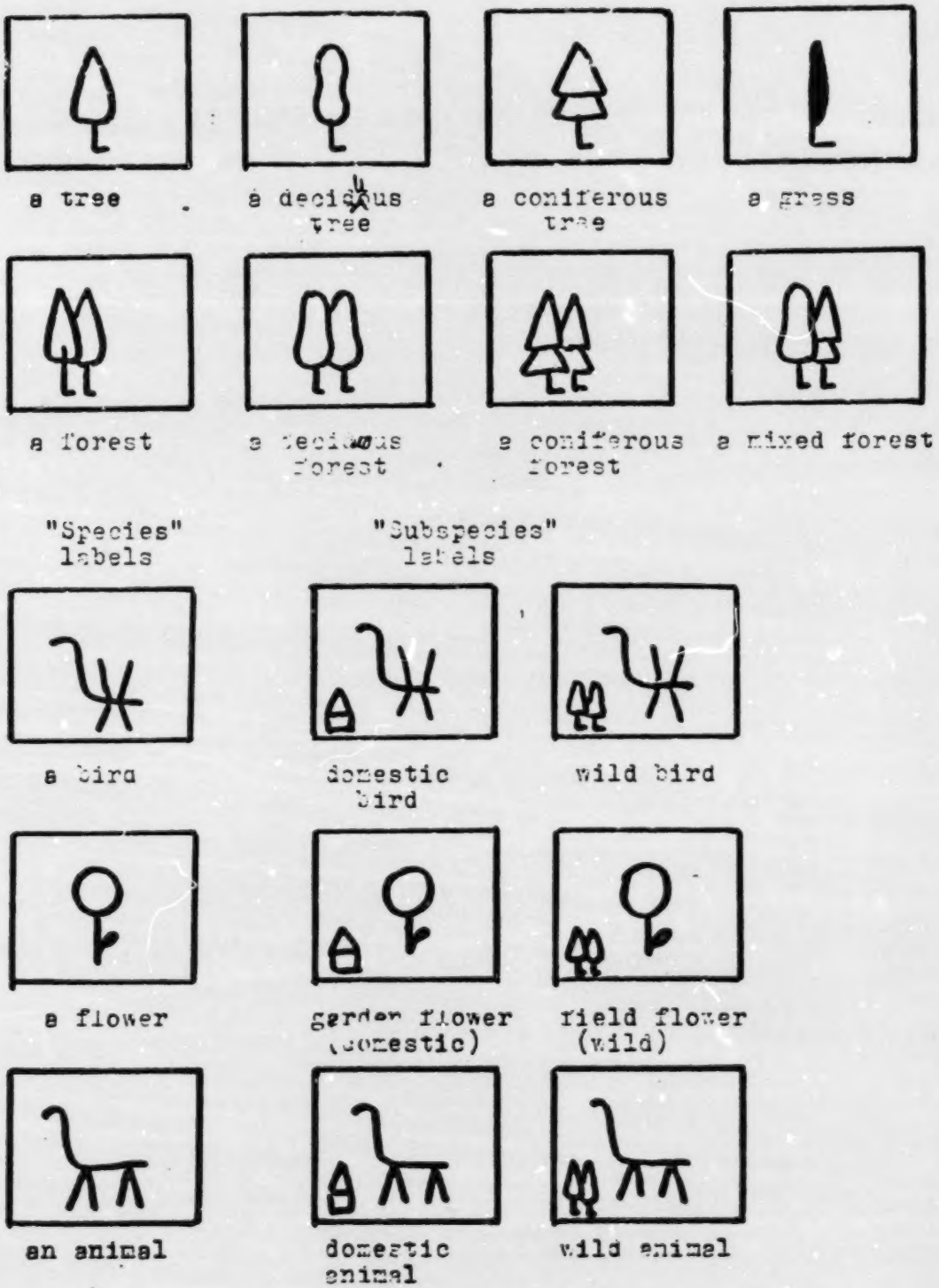
An Attempt to Create a System of Iconic Signs for Teaching Purposes

In the previous studies iconic signs did not constitute a uniform system. They were labels which denoted group qualities of objects, and denotation was the only function they played. In our new studies we introduced iconic signs which entered into relations among themselves, thus changing the range of meaning of the basic sign. For instance, a double sign of a tree denoted a forest, whereas a sign of a deciduous tree added to a sign of a coniferous tree denoted a mixed forest.

Apart from such simple combinations we also used labels with symbols of species and of their various sub-species. A "species" label contained a graphic sign referring to the characteristic traits of a given species (e.g., wings, the number of limbs), whereas a "sub-species" label contained the symbol of the species plus an index of a sub-species (e.g., domestic animals were represented by a sign of a house, wild animals by a sign of a forest).

There were two variations of the experiment: a) we used a set of iconic labels mentioned above, and b) we used equivalent verbal labels. As our material we used realistic pictures of such objects as trees, various types of forests, flowers, birds, and animals (see Note 2). The subjects' task was to classify those pictures following the labels presented in Figure 2. Besides, deaf children were to describe a picture comprising more objects (forest, a field with plants and animals) using the two kinds of labels mentioned above.

Figure 2.
Patterns of labels.



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As far as classification was concerned, a similar procedure to the experiment of the first stage was applied (see Note 3). The tests were carried out on a group of 30 pupils (aged 11 to 14;2) from the 5th, 6th, and 7th forms of an elementary special school for the deaf. They were divided into two groups: A and B. In the first series of the experiment Group A was learning a taxonomy of plants and animals exclusively on the basis of iconic signs, whereas Group B was learning it exclusively on the basis of verbal signs. After five months testing was repeated in an analogous arrangement. In the third series, however, which took place some days after the second one, the kind of labels given to two groups was changed: Group A used now verbal signs, and Group B used iconic ones.

A preliminary analysis of the mistakes made by the deaf children during the experiments shows that in each case the use of iconic signs guarantees better results (Table 3).

Table 3

Number of Elements Used Wrongly

	Series I			Series II			Series III		
	Group	Number of Elements	%	Group	Number of Elements	%	Group	Number of Elements	%
Iconic Signs	A	15	5,66	A	24	9,05	B	14	5,28
Verbal Signs	B	55	20,76	B	74	27,92	A	83	31,32

In the total number (265) of mistakes--53 mistakes or 20% concern the task where iconic signs were used. As far as the task with verbal signs was concerned, the children made 212 mistakes, or 80% of their total number.

Let us consider the results obtained by Group A. In the first two series of the experiment this group used iconic signs in their tasks, whereas in the third series they used verbal signs in the same task. One could expect that thanks to a

priori experience the results of the third series would correspond to the previous results. However, in this series the deaf pupils made the highest number of mistakes. At the same time Group B, with a reversed procedure in the third series using iconic signs, achieved the best results as compared with the others.

The efficiency of learning based on the two kinds of signs will become still clearer, when we analyze a list of elements used correctly. To facilitate comparison, Table 4 gives, apart from absolute numbers, also a proportional relation with a total number of elements contained in the task.

Table 4

Number of Elements Used Correctly and a Proportional Relation (x100)

With the Total (165) Number of the Elements Used in the Task

	Series I			Series II			Series III	
	Group	Number of Elements	% Relation	Group	Number of Elements	% Relation	Group	Number of Elements	% Relation
Iconic Signs	A	155	93,93	A	155	93,93	B	156	94,54
Verbal Signs	B	129	78,18	B	125	75,75	A	111	67,27

The results obtained when iconic signs were used are almost accurate and always reach more than 90% of all the elements used. The labels with verbal signs did not lead to equally good results. A more detailed analysis, where individual differences would be taken into consideration, is likely to reveal some other phenomena which so far have not been noticed. A preliminary comparison shows that the use of iconic signs allows for a more precise definition and a better separation of a part from a larger whole. "Iconic" descriptions are both richer and more adequate than verbal ones.

Having found that the classification of experimental building bricks went better when given categories were represented by iconic signs, whereas it was more

complicated when verbal signs were introduced, we were vexed by the question whether the use of a concrete school material would yield similar results. Because of their univocal character, the results of the experiment presented above seem to dispel fears that the detected regularities would not be of any practical significance. It does not mean, however, that we are going to be satisfied with the attempts described here. To render the results more convincing the tests should be repeated, this time using materials from other school subjects (e.g., mathematics). Besides, in our further studies we shall ascertain what are the possibilities of expressing other intellectual operations through symbols taken from iconic language.

Conclusions

The questioning of accepted truths may be an occupation satisfying enough for a scholar. However, practice shall ask us about the aim of such an action or about benefits which may result from it. In turn, frequently the demands of practice may seem prosaic to us till we try to meet them. Then it may appear that our discoveries which destroy the existing order of things cannot really fulfill those sometimes simple and obvious needs. After all, what is the meaning of our statement that iconic and not verbal signs are the best vehicles of information for the deaf? Does it mean that from tomorrow on we will stop tormenting deaf children by making them lipread, introducing instead thousands of labels with graphic signs? If so, what sort of signs shall we use? Is it enough to introduce a local system (on the level of a school or a country)? Should not we wait till a universal international system is created? How to treat the role of natural sign language? Those and many more different questions came to our minds when we realized the results of our investigation. There were more questions because the results, surely not accidental and forseeable, did not agree with the generally assumed truisms. It is worth adding here that it would be much easier to give

meaning to any other set of results. After all, if the process of learning based on visual display had proved most efficient, then one could say that it mirrored a natural intellectual attitude of the deaf. It remains to be said that classification on the level required in the experiment calls for a more advanced skill than only a simple processing of perceptual data.

Proving that verbal symbols are of highest value may become a stimulus to even more intense teaching of sound language. In such a situation failures in this respect would indicate a poor efficiency of teaching and would stimulate us to look for explanatory factors. The statement that iconic signs may be most advantageous for developing operations involving symbols makes us frame a new theory.

It would be an unacceptable over-simplification to assume that our experiments prove that it is possible to think without language. Such a conclusion may suggest itself when we consider simple tasks involving the usage of a few or several loose labels. However, let us pay attention to the last series of tests where the existence and functioning of a few syntactic rules, whose application changes the meaning of the basic sign, is explicit. Formally speaking, we may state then that this is already a two-class system bearing structural features of language.

Language containing iconic signs is much more logical for the deaf than sound language. This difference is especially noticeable when we deal with an inflectional and postpositional language such as Polish. The structure of prepositional languages seems to be closer to the structure of an iconic sign.

An advantage of an iconic sign is that being structurally connected with the object it denotes, it can be explained not only by means of a social convention as is the case of a majority of signs in sound language. In turn, as it is not an image of the object it denotes, it facilitates the appearance of at least a

sensual relation of denoting. The next step is a possibility of carrying out operations on signs after introducing syntactic rules and learning that such operations result in changes in meaning. It is not the whole range of possible operations. The next task would be to introduce operational signs resembling function words. The studies of the deaf indicate that they find those parts of speech most difficult to understand, so it seems necessary to continue research in this direction.

In the natural development of a hearing child the development of speech overlaps with the development of intellectual operations. According to Piaget (1966), the period of the two first years of life at the end of which the process of shaping speech takes place, is characterized by constructing the categories of object and space as well as of causality and time. For the time being they remain practical categories and refer to actions without being intellectual notions. An ability to perform operations in each of the spheres mentioned above in a different way contributes to the rise of the language system. What is extremely important is the achievement of an appropriate level in the sphere of time operations since they enable us to project the sequential qualities of language. On the other hand, spatial operations form the basis of a simultaneous organization. For a majority of the deaf they are not a problem, whereas time operations seem to be closely connected with aural perception, as the deaf are noticed to be particularly deficient in this respect. Even the material which is perceived visually but presented successively is remembered less well than the identical material presented simultaneously. It was Rozanowa who investigated this problem, and the results were confirmed in the studies carried out by our M.A. candidates (see Note 4). It is worth adding that the perception of cause-and-effect relationships, which at least in the phase of concrete operations are closely connected with time operations, is impaired in the deaf as well.

A technique used to improve symbolic operations by means of learning sound language defies any sound principles of rehabilitation. In every other case we would begin with stating the strong points of a patient which should become a basis of a function which is to be reconstructed. Here one starts from the end and builds a construction based in fact almost on nothing--since in what way minute remnants of hearing and observation of subtle movements of speech organs of a sequential character contribute to the rise of a complicated language system, which is a proper vehicle for developing thinking.

Taking into consideration studies and observations, we suggest the application of a different program. Its essence is that one begins with finding out a deaf child's abilities and not with the regularities revealed in the development of a normal child. It follows that first of all one should pay attention to simultaneous operations. This assumption not only settles the question of what kind of signs should be used to denote objects, to denote their mutual relationships and to express more complicated syntactic and semantic functions, but also how the expressions containing these signs should be presented. At least at the outset one will have to accommodate the program to the natural abilities of deaf children.

Denotation and understanding changes which result from various connotations are the first two operations on introduced signs. Also hearing and speaking children have some problems with denotation and connotation, however, thanks to an easy contact by means of language, they solve them from day to day. The period when those operations are shaped is above all the question-study period. At the same time this parallel indicates the best period to introduce signs. It should correspond to a period when small children bombard their associates with questions about objects and relations between them.

While working with a deaf child we should realize that subsequent states of its development will be recorded in the sphere of operating on first real objects, then their representative images, and finally symbolic representations. The application of such methods as the one presented above demands patient waiting till subsequent cortical structures enable a transition to a high operational level. Such a transition cannot occur automatically and must be preceded by a stimulation of lower structures. The time which has to elapse between the moment when a deaf child grasps the essence of denotation and connotation and a possibility of using the signs he has learnt in intellectual operations on a logical and formal level should be utilized to reconstruct sequential functions. Without acoustic sensations, full restitution of this function will be probably difficult. If we want to prepare a child to acquire a universal system of language which will enable him to communicate with his speaking associates and to assimilate their cultural achievements, we will have to find a way of at least minimizing this defect.

The course of a teaching process cannot be merely a result of adopting a particular theoretical concept. Certainly, it has to be tested before it becomes a routine method used in everyday proceedings. Meanwhile, we would like to recommend now a slightly different procedure in the education of the deaf on the basis of our empirical results. This procedure should both stimulate intellectual processes and improve the linguistic skills of the deaf.

Reference Notes

1. See: A series of M.A. theses written in 1968-72 and supervised by the Institute of Defectology and Rehabilitation of the Jagiellonian University.

2. Materials used in the experiment, especially names and a type of taxonomy were selected after consulting with teachers from a school for the deaf.

3. The testing was carried out by a psychology student, K. Boczar.

4. Sołowiew, I. M., Szyf, Z. I., Rozanowa, T. W., Jaszkowa, N. W. Psychology of Deaf Children. Warszawa, 1976.

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